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Condensate Recovery & Harvesting

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INTRODUCTION

With the adoption of building service systems requiring designs to minimize their environmental impact, innovative as well as obvious natural resource conservation measures are being explored.

One element of conservation considered in design is to minimize water usage in buildings. Modern designs often use green design practices suggested by organizations like the US Green Building Council and their LEED new construction guidance, where points toward receiving an overall rating are assigned to reducing annual water consumption by 20% and 30% from baseline fixture flow rates determined by the Energy Policy Act of 1992 (USGBC, 2007). Hydronic systems makeup for equipment such as cooling towers is not generally included in building baseline water consumption rates for LEED, however, should be considered in whole building water consumption estimates. Typical water conservation measures are utilizing low and zero flow fixtures, utilizing grey water for non-potable uses, and minimizing high water demand landscaping. Other, less common, water conservation measures utilizes the harvesting of water producing sources to offset the annual water consumption to achieve a net annual water reduction. These water producing sources include storm water recovery and air conditioning condensate harvesting.

Condensate from air conditioners, dehumidifiers, and refrigeration units can provide facilities with a steady supply of relatively pure water for many processes. Laboratories are excellent sites for this technology because they typically require dehumidification of large amounts of 100% outside air (DOE, 2005).

Another element considered in building design is indoor air quality and building envelope pressurization. Ventilation for Acceptable Indoor Air Quality, ASHRAE Standard 62.1- 2004 recommends appropriate ventilation levels for various building and occupancy types. If buildings have excessive exhaust requirements due to fume hoods, user required air change rates, or other process exhaust, the minimum ventilation air requirements are potentially higher. Outdoor ventilation air commonly contains a higher moisture concentration and temperature than what is desired in the space. Conditioning this air by both reducing the temperature as well as reducing the moisture content is required.

Because some designs require increased levels of outside ventilation air for a variety of reasons, the potential to recover the energy being expelled by the exhaust system and transfer to the incoming ventilation air is high. Due to this potential, ASHRAE has incorporated policy regarding energy recovery, outlined in the Energy Standard for Buildings except Low-Rise Residential Buildings, ASHRAE Standard 90.1. To satisfy ASHRAE 90.1, fan systems that have a design air flow rate of 5000 cfm (2358 L / sec) or greater and have a minimum outside ventilation air flow that is equal to 70% or more of the supply air shall have an energy recovery system with at least 50% recovery effectiveness

(ASHRAE, 2004). There are exceptions to this requirement, however for the purpose of this paper, no exceptions are taken.
To centralize the process of pre-conditioning ventilation air and the recovery of exhaust air energy, large energy recovery units or DOAHUs with energy recovery means are commonly used. These units are designed to provide preconditioned ventilation air either directly to the occupied space or ducted to an additional AHU. All building exhaust is also ducted to these units, which exchanges sensible and latent energy with the incoming ventilation air.

There are several types and configurations of AHU available for use. They have heat recovery means, either by an enthalpy wheel, glycol run around loop, air-to-air heat exchanger, or others. In addition, they often have cooling and heating coils, as well as humidifiers depending on the application. The type of AHU studied in this paper is one with an energy recovery device, pre-heat and cooling coil downstream of the recovery device, and a heating coil in the reheat position,
The units pre-condition large quantities of moisture laden air down to a more moisture neutral state, where the humidity ratio is close to the delivered supply air humidity ratio. This process produces large quantities of condensate, which is commonly discharged to the sanitary sewer systems. Some water treatment facilities operate at near capacity and do not allow or discourage condensate disposal into the sanitary sewer system.
The focus is to determine the feasibility of coupling both the water conservation and indoor air quality and building envelope pressurization elements of design by harvesting air conditioning condensate for non-potable water supplementation in large commercial, institutional, and medical buildings, where large volumes of outside air are required.
Cooling Tower Makeup Water Usage. To estimate the annual makeup water consumption used for cooling towers, the condenser system load was first determined. Since the case study building contained other chilled water using devices in addition to the AHUs, simply using the coil loads for this equipment as the cooling tower load was incorrect. A whole building cooling tower estimated load was necessary to determine the makeup water requirement. Based on 2007 weather data, the sensible and latent coil loads for the AHUs need to be determined using the operating parameters described. These daily coil loads were converted to percent load based on the maximum design coil load for the AHUs. The percent load profile must be used to determine the daily chiller load by multiplying the maximum chiller capacity by the percent load building profile determined previously. Once the daily chiller load was determined, the cooling tower makeup water demand was calculated using the following equations.
Equation 9 represents heat transfer due to evaporation. It is assumed that all heat transfer dissipated by the cooling tower is 90% due to evaporation; however the actual ratio of sensible and latent components varies with outdoor air temperature and humidity (Marley, 1983).
[q.sub.tower] = 1.2 * ([q.sub.bldg]) (Accounting for compressor heat) (10) [q.sub.evap] = ([q.sub.tower]) * 90% (11)
To account for heat generated by the chiller, the total heat rejection load on the cooling tower is 1.2 times the building chilled water load. Using equation 9, the following relationship can be determined, where the evaporation rate is the total cooling tower heat rejection load divided by the enthalpy of evaporation, shown in equation 13. For consistency, system was analyzed only during days where the outside air temperature was above 65 [degrees]F (18.3 [degrees]C).

[[for all].sub.evap] = [m.sub.a] * ([DELTA][omega]) (12)
[[for all].sub.evap] = [[q.sub.evap]/[h.sub.fg@85[degrees] F]] (13)

Where:
[[for all].sub.evap] = cooling tower makeup due to evaporation, [lb.sub.v]/h ([kg.sub.v]/h)
As the water of evaporation exits the cooling tower in a pure vapor state, the dissolved solids left behind increases in concentration in the re-circulating water. Given no control, the total dissolved solids (TDS) level in the re-circulating water can potentially damage the tower, condenser, and related equipment. To prevent this, a portion of the re- circulated water is continuously drained from the system and replenished with clean water. This process is called "blowdown". To calculate the quantity of blowdown, the following equations were used:

B = [[[[for all].sub.evap] - ((C - 1) * D)]/(C - 1)] (14)

where

C = cycles of concentration (estimated at 4, local municipal requirement)
D = drift (estimated at 0.0002 times condenser water flow)
This shows the daily estimated cooling tower makeup water demand as well as the potential condensate volume. The annual makeup water required for the cooling towers due to evaporation and blowdown, when compared to the annual condensate produced by the DOAHU, supplementing the cooling tower makeup water with condensate has the potential of an estimated 16% water savings
The review indicates that the condensate production from a large dedicated outdoor air handling unit or series of units can completely supplement water closet and urinal water demand annually, which could potentially supplement the landscape irrigation system, or reduce the cooling tower makeup demand by 16% annually. It is shown that water conservation as well as indoor air quality and building pressurization design elements can be coupled to produce a better overall building service design that would routinely not be considered. condensate recovery/harvesting is an environmentally conscious option and should be considered in addition to low and zero flow plumbing fixtures when making water conservation design decisions.

This review focuses on dedicated outdoor air handling unit condensate harvesting, however units with return air and outside air are widely used in commercial buildings. To apply the proposed methodology using a whole building approach to condensate harvesting, systems of these types should be considered. In addition, retrofits of existing building with large outside air requirements, such as hospitals, laboratories, and dormitories should be considered.

REFERENCES

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